Notes on Revised Camera/LED Driver Interface
for COUPP-2L 2010 at SNOLAB

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For photography, the COUPP-2L bubble chamber is illuminated with an array of 10 LUXEON Star high power LED units arranged in a "T" pattern with five LED's across the top bar and five LED's on a central vertical bar. The five LED's in each group are wired in series, and the two groups are wired in parallel strings. The LED's are powered using a large HP bench supply. The current through the array is adjusted using the current limit of the power supply. The two FireWire cameras are triggered using an external HP pulser module. The LED's are switched on by the logical "OR" of the two "camera active (IntEna)" signals from the FireWire cameras. We "tune" the cameras by the following sequence:

1) Set the Supply Current Limit to zero
2) Set the Supply Voltage to Max
3) Raise the Supply Current Limit to attain the desired brightness, while we:
4) Ensure that the Average Supply Current does not exceed the value determined by $I_{\text{Supply Max}} = 2*I_{\text{LED MAX}}*f_{\text{duty}}$, where $I_{\text{LED MAX}} = 1.4$ amps is the maximum instantaneous current through the LUXEON Star LED, $f_{\text{duty}} = 0.2$ is the duty factor of the LED's, and the factor of 2 arises from the two parallel strings driven by one current source.

This existing Camera/LED interface and LED driving machinery on COUPP-2L has some obvious drawbacks when considered for use in the remote SNOLAB environment. These include

1) We do not have remote adjustment capability for any of the parameters of the system including
   a. The Camera Frame Rate
   b. The LED Operating Current
   c. The Maximum LED Current and Voltage
   d. The Current Split between the Two LED Strings

2) We do not have any read-back capability for the LED forward voltage. This is an important indicator of the health and welfare of the LED.

3) We do not have proper current limiting protection for the LED's. This is because we power two strings in parallel. If one LED fails, then all the current will be shunted to the other leg and will likely blow out those LED's as well.

Proposed Solution Based on Commercial MIGHTEX LED Controller:

The MIGHTEX SLC-SV04-US Universal LED Controller seems to have all of the features we need for a pretty good system. This unit provides:

1) Four separate computer controlled current source channels
2) Each channel can be operated in one of three modes
    a. DC programmable fixed current output
    b. STROBE pulse train with programmable "ON" current and duty factor
    c. External Trigger mode (this is what we will use.)

The idea is as follows:

1) Package this unit with its 24V power supply in a single 1-U chassis

2) Use two channels in triggered mode to drive our two strings of LED's

3) Use one channel in strobe mode to drive the camera trigger inputs.

4) We could still form the "OR" of two cameras to drive both LED outputs,

5) OR, we could let each camera drive one LED chain. This would work fine as long as both cameras are active, but will cause on LED string to drop out if one camera drops out. I think that's OK, since we do not want to run with one camera…

6) We can consider putting all the signals (4 wires per camera, 4 wires LED drive) on a single 12-pin Burndy, or we might have one connector for LED and one for the two cameras. …or keep it as is and use smaller 4-pin connectors for the cameras. We can think about this for a little while…

APPENDIX I: Basler A602f Interfacing Details

Pin	Designation
1	Output Port 3 -
2	Output Port 2 -
3	Output Port 1 -
4	Output Port 0 -
5	Input Port 0 +
6	In Gnd Comm
7	Out VCC Comm
8	Input Port 2 +
9	Input Port 1 +
10	Input Port 3 +

Table 2-2: Pin Assignments for the RJ-45 jack

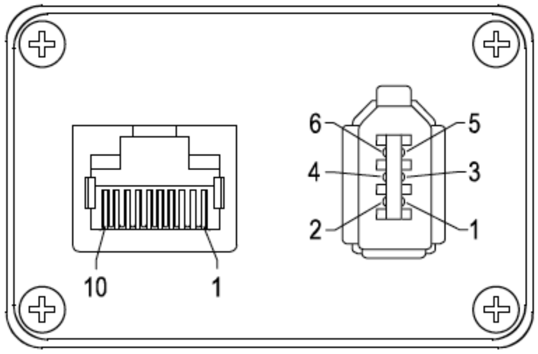

Figure 2-2: **A600f** Pin Numbering

ⓘ	The camera housing is connected to the cable shields and coupled to signal ground through an RC network (see Figure 2-3 for more details).

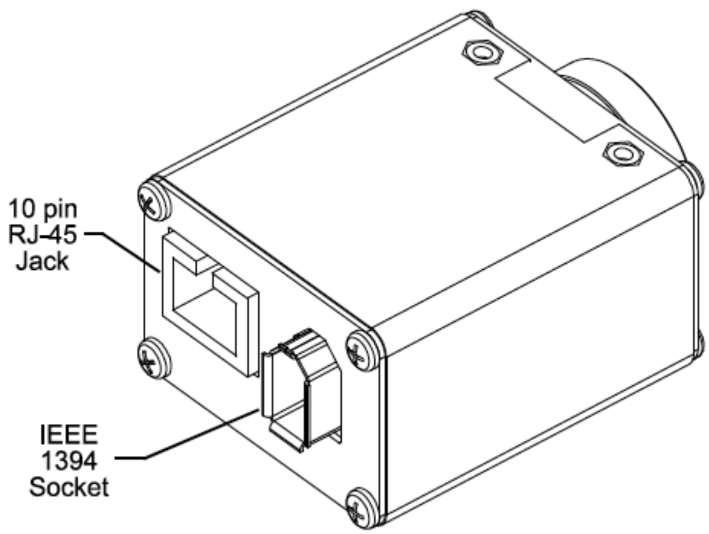

Figure 2-1: Camera Connectors

2.5 Input and Output Ports

2.5.1 Input Ports

A600f cameras are equipped with four physical input ports designated as Input Port 0, Input Port 1, Input Port 2, and Input Port 3. The input ports are accessed via the 10 pin RJ-45 jack on the back of the camera. See Table 2-2 and Figure 2-2 for input port pin assignments and pin numbering.

As shown in the schematic in Figure 2-3, each input port is opto-isolated. The nominal input voltage for the LED in the opto-coupler is 5.0 V (± 1.0 V). The input current for the LED is 5 to 15 mA with 10 mA recommended.

For each input port, a current between 5 and 15 mA means a logical one. A current of less than 0.1 mA means a logical zero.

By default, Input Port 0 is assigned to receive an external trigger (ExTrig) signal that can be used to control the start of exposure. For more information about the ExTrig signal and for information on assigning the ExTrig signal to a different input port, see Section 3.2.5.

ⓘ	As stated above, the nominal input voltage for the LED on each input is +5 VDC. If a 560 Ohm resistor is added to the positive line for an input, the input voltage can be 12 VDC. If a 1.2 or 1.5 kOhm resistor is added to the positive line for an input, the input voltage can be 24 VDC.

2.5.2 Output Ports

A600f cameras are equipped with four physical output ports designated as Output Port 0, Output Port 1, Output Port 2, and Output Port 3. The output ports are accessed via the 10 pin RJ-45 jack on the back of the camera. See Table 2-2 and Figure 2-2 for output port pin assignments and pin numbering.

As shown in the schematic in Figure 2-3, each output port is opto-isolated. The minimum forward voltage is 2 V, the maximum forward voltage is 35 V, the maximum reverse voltage is 6 V, and the maximum collector current is 100 mA.

A conducting transistor means a logical one and a non-conducting transistor means a logical zero.

By default, Output Port 0 is assigned to transmit an integration enabled (IntEn) signal that indicates when exposure is taking place. For more information about the IntEn signal, see Section 3.4.

By default, Output Port 1 is assigned to transmit a trigger ready (TrigRdy) signal that goes high to indicate the earliest point at which exposure start for the next frame can be triggered. For more information about the TrigRdy signal, see Section 3.3.

The assignment of camera output signals to physical output ports can be changed by the user. See Section 6.7.10 for more information about configuring output ports.

ⓘ	By default, output ports 0, 1, and 2 are set to a low state after power on. Output port 3 is initially set to low but will go high approximately 100 to 300 ms after power on. Output port 3 will remain high for approximately 750 ms and will then reset to low.

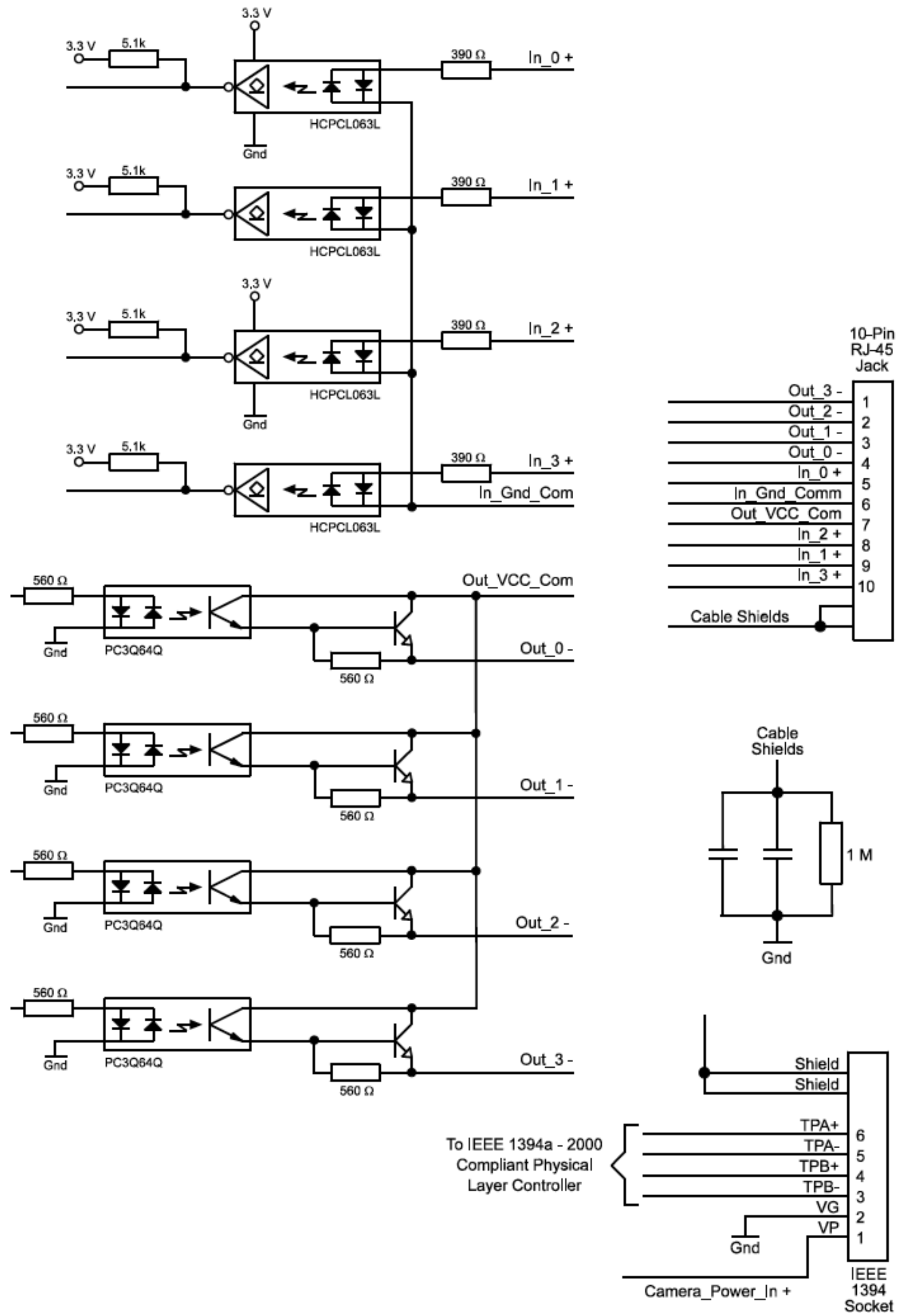

Figure 2-3: I/O Schematic

2.5.3 Typical Input Circuits

Figure 2-4 shows a typical 5 VDC circuit you can use to input a signal into the camera. In Figure 2-4, the signal is applied to input port 1.

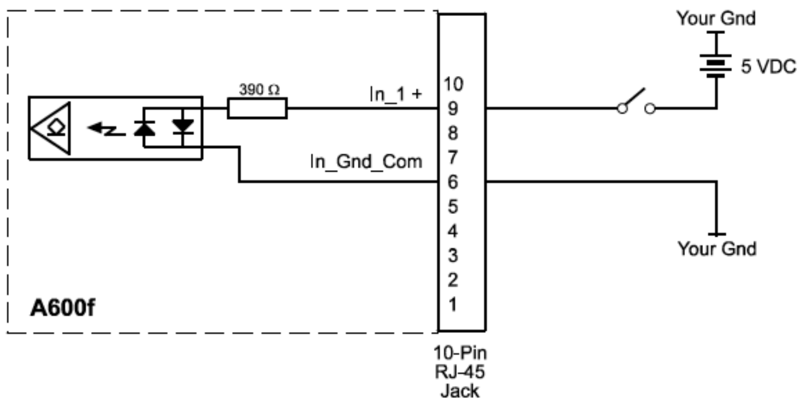

Figure 2-4: Typical 5 VDC Input Circuit

Figure 2-5 shows a typical 24 VDC circuit you can use to input a signal into the camera. Notice that an external 1.2 k resistor has been added to the circuit. This will result in approximately 15 mA being applied to the input. In Figure 2-5, the signal is applied to input port 3.

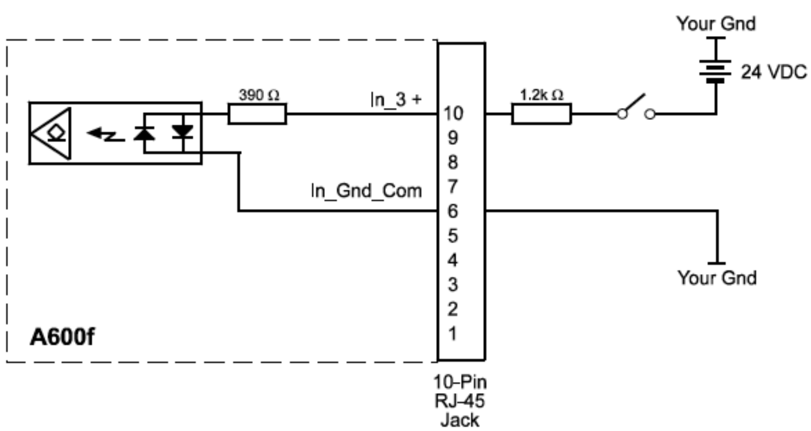

Figure 2-5: Typical 24 VDC Input Circuit

2.5.4 Typical Output Circuits

Figure 2-6 shows a typical circuit you can use to monitor an output port with a voltage signal. The circuit in Figure 2-6 is monitoring camera output port 1.

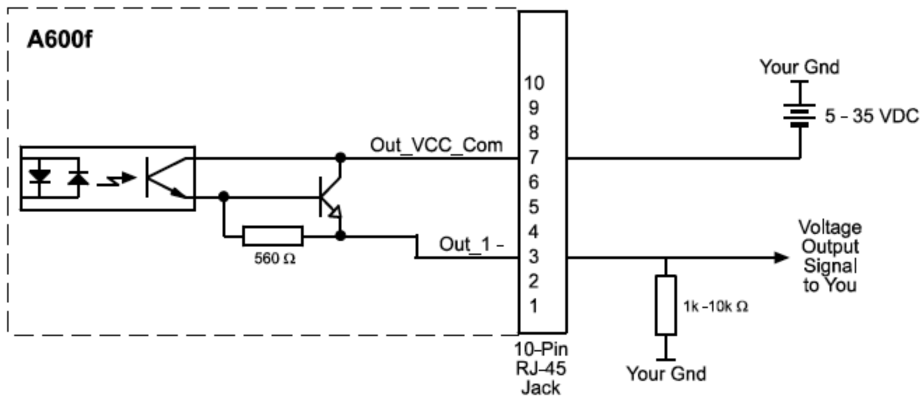

Figure 2-6: Typical Voltage Output Circuit

Figure 2-7 shows a typical circuit you can use to monitor an output port with a LED or an optocoupler. In this example, the voltage for the external circuit is 24 VDC. Current in the circuit is limited to approximately 10 mA by an external 2.2k resistor. The circuit in Figure 2-7 is monitoring camera output port 2.

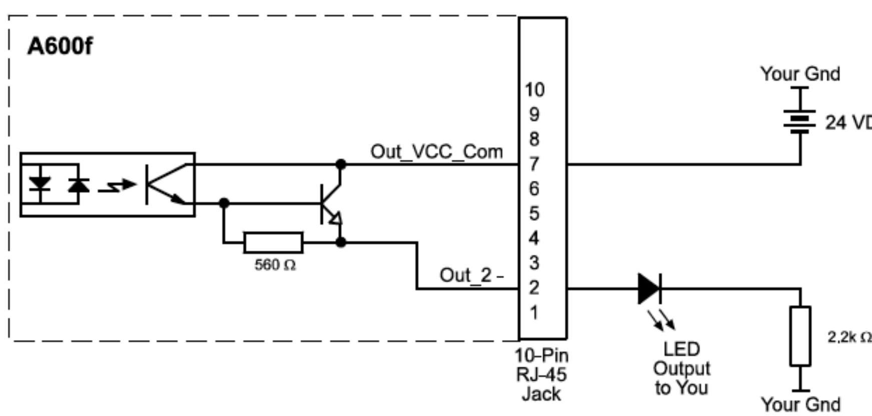

Figure 2-7: Typical LED Output Signal